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Title: Window Test Stand Status and Future Work

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Window Test Stand Status and Future Work

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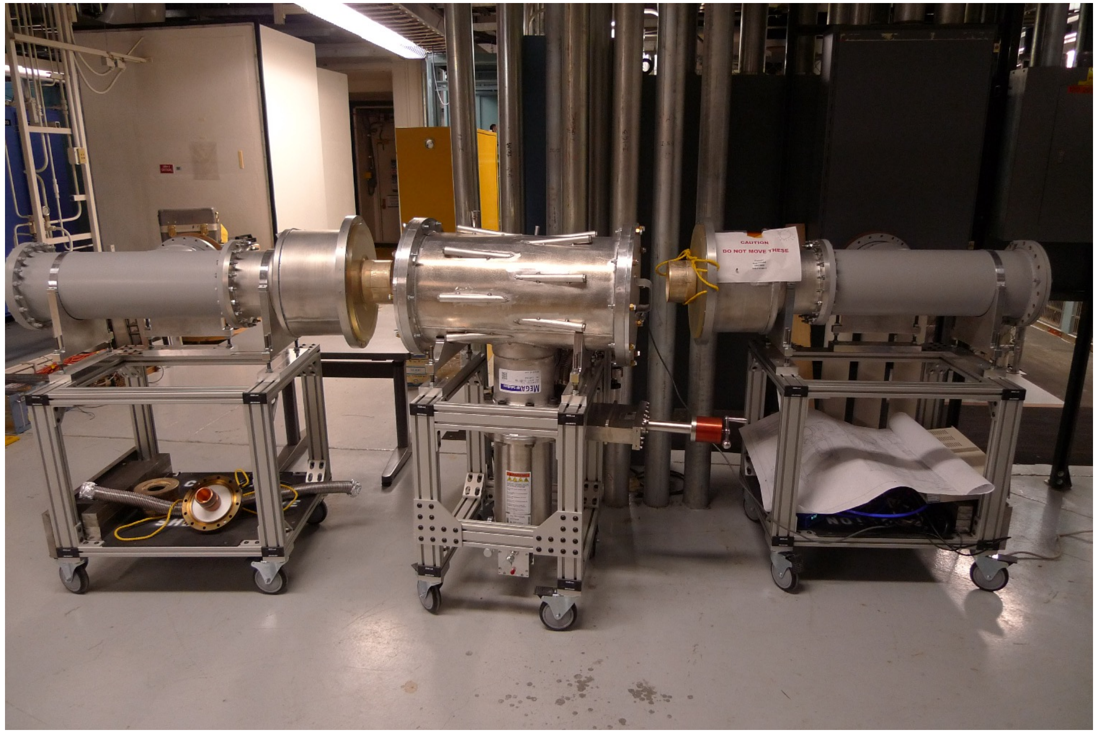
Content

- Challenges to getting the window test stand running that were addressed.
  - Initial design of half-anchor connector was insufficient.
  - Accommodation of non-Rexolite windows required engineering.
- Planned testing and remaining work.

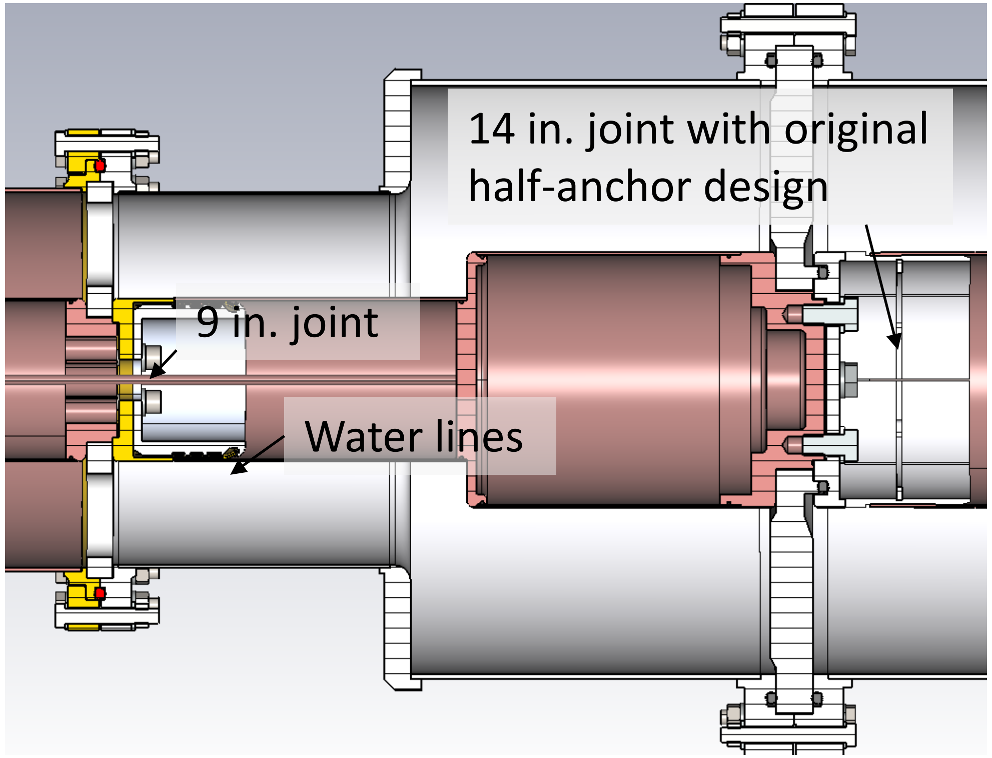


Disassembled window test stand

Challenge 1: Half-anchor redesign

The original half-anchor that acts as the electrical connection to the center conductor at the window location originally used a high friction design. This friction was greater in the 14 in. coaxial joint than in the 9 in. joint, which caused the smaller diameter joint to pull apart first, potentially damaging the test stand anytime a window was to be replaced.

Original half-anchor design



9 in. to 14 in. coaxial line transition

New half-anchor connector

The new half-anchor connector uses RF finger contacts. These finger contacts are more flexible than the original anchor, and so they have lower friction for easy removal. The first row near the step carries the RF current, second is for leakage and any residual RF current. This design is fairly common in high power coaxial lines, and the friction of the slip-fit is much lower. This solves the problem we discovered with the previous design.

Half-anchor connectors with new finger stock design

Half-anchor connector installed in window test stand

Challenge 2: Use of ceramic windows in the test stand

- The test stand was designed to test Rexolite windows, and changing to a ceramic like Alumina will increase the power reflected to the source.
- The Rexolite windows that the test stand was designed for have geometric features that would have been difficult to manufacture in ceramic, so the ceramic window was modified to be flat on both vacuum and air side.
- These two challenges required further engineering.

CST Simulations

- Several window configurations were run in CST to find the power that would be reflected to the RF amplifier.
- Simulations did not identify concerns with using a flat window surface.
- Ultimately decided on using a flat disk geometry of 0.4 inches thick.

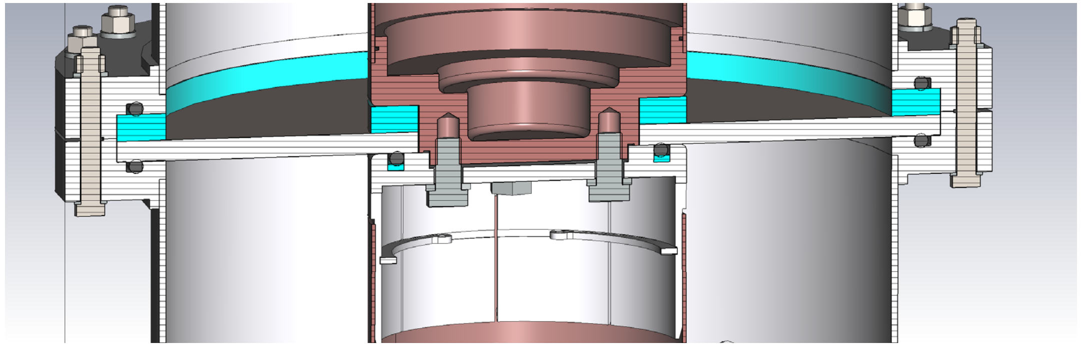
Configuration	S_{11}	Reflected power for 1 MW incident power	Reflected power for 2 MW incident power
Rexolite windows	0.0210	0.4 kW	0.8 kW
One alumina window, same geometry as Rexolite	0.3255	106.0 kW**	211.9 kW**
Two alumina windows, same geometry as Rexolite	0.5622	316.1 kW**	632.1 kW**
One quartz window, same geometry as Rexolite	0.0764	5.8 kW	11.7 kW
Two quartz windows, same geometry as Rexolite	0.1318	17.4 kW	34.7 kW
One alumina window, 0.45” thick, geometric features retained	0.1998	39.9 kW*	79.8 kW*
One alumina window, 0.2598” thick, geometric features retained	0.1193	14.2 kW	28.5 kW
One alumina window, flat disc, 0.4”	0.1211	14.7 kW	29.3 kW

*Effect of this power on RF amplifier is untested

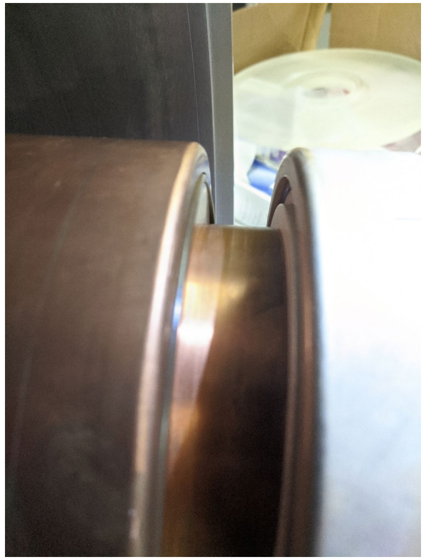
**This power is too much to be feasible

Test stand modifications to accommodate flat ceramic window

- The thinner design will now require spacers to make up for the reduced window thickness.
- The o-ring groove must be modified.
- The Rexolite window fits against an o-ring on the air side center conductor. Using a thinner window removes this contact and creates an air leak path.
- The half-anchor connector must be modified for these two issues. These modifications and the spacers are being finalized and manufactured.



Thin disk window with the space created by the geometry change shown in blue.



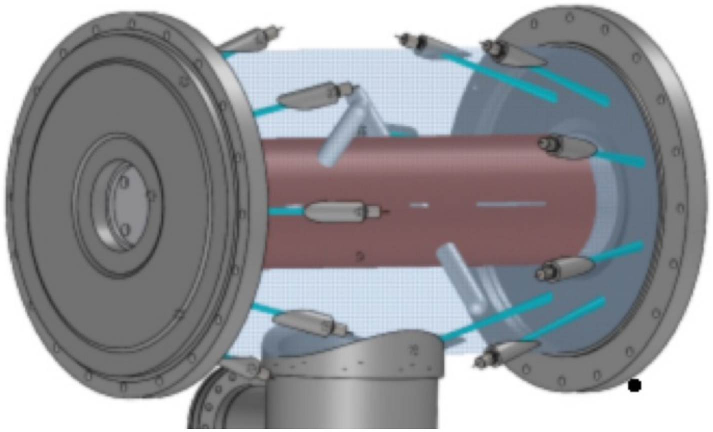
The o-rings on the air side (left) and vacuum side (right) on the test stand.

Proposed testing

- First, the test stand will be assembled and pumped down to ~1e-7 torr. Being capable of holding vacuum is essential in testing the window performance with RF.
- Next, RF will be passed through the test stand into the load. Low duty factor and low peak power will be used initially, then slowly increased depending on the window performance.
- A good window will continue to hold vacuum, avoid multipactor, and not get too hot after several hours with RF power.
- A data acquisition system (DAQ) has been developed to gather relevant information and provide protection during testing.

Diagnostic 1: Window temperature measurements

- Long wave IR measurement will look at several spots around both windows.
- An unevenness in heating (i.e. some spots are hotter than others) might be indicative of uneven coating or multipactor.
- Ideally, non-coated and coated windows should both be tested. This cannot necessarily be done simultaneously (i.e. with the upstream and downstream windows) as multipactor will be attracted to the downstream window.
- Heating of the window can be precisely characterized.



Visualization of IR sensor measurements of window temperatures. The sensor placement shown here differs from the final design (shown below) such that the spot that the window temperature is taken is larger than shown here.

IR sensors installed in the vacuum portion of the window test stand.

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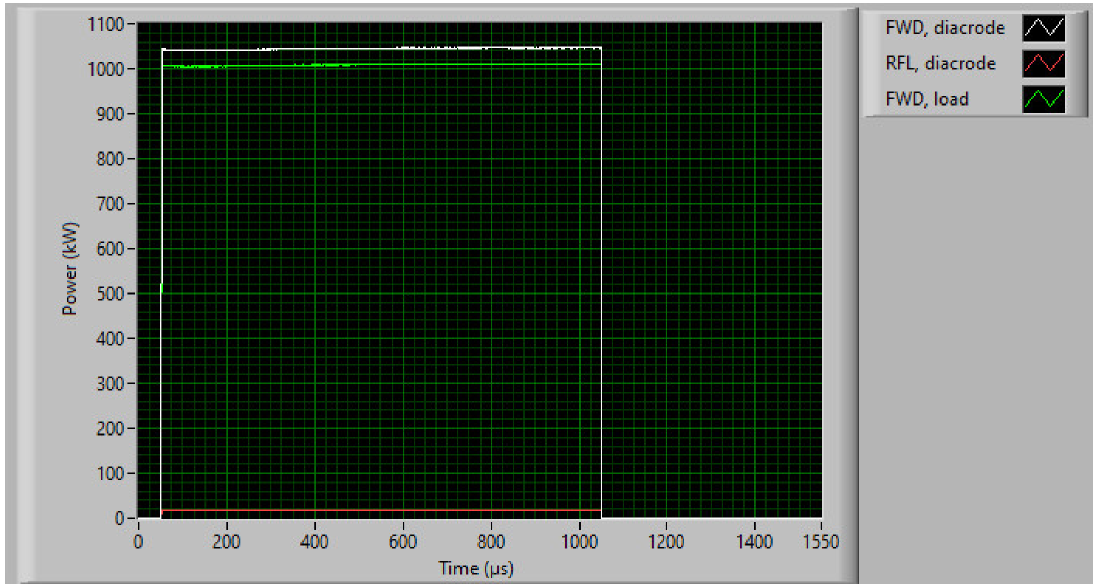
Diagnostic 2: RF power

- RF power will give an indication of the window performance.
- The average power should be correlated to the window temperature and the vacuum level.
- Difference in forward power before and after the test stand can indicate the power dissipated in the test stand.
- RF waveforms can be indicative of multipactor. Additionally, a large increase in reflected power can also indicate multipactor.



Example of RF power waveforms. Deviations from this expected waveform such as steps or oscillations are indicative of multipactor.

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Data logging

- Vacuum level read along with the sensor temperatures in DAQ.
- Waveforms captured and up to the most recent 1 second are displayed at full duty factor. Up to the most recent minute are displayed for lower duty factors.
- Most recent 30 seconds of window temperature and vacuum levels are displayed.
- Collected power waveforms and temperature + vacuum reading can be written to a file on demand.
- Most pertinent information such as power levels at specified point in the pulse and temperatures are logged automatically at regular intervals.

Interlocks

- Interlocks are added to prevent damage to the window and the rest of the system.
- Water interlock separate from DAQ for quicker response.
- DAQ interlocks should there be an issue with the window. The set interlocks are:
  - Window temperature over a set point
  - Standard deviation of window temperatures over a set point indicating uneven heating
  - Vacuum level

Remaining work

- Manufacture the bullet and spacer to accommodate the thinner ceramic window.
- The first tests with Rexolite windows are being run at the moment. This will allow the any peculiarities of the system to be understood and corrected if possible.
- Finally, tests can be run with ceramic windows.